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Prices of unhealthy foods, Food Stamp Program participation, and body weight status among U.S. low-income women†

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Abstract

This paper examines the interactive effect between the price of unhealthy foods and Food Stamp Program participation on body weight status among low-income women in the United States. We merged the panel data of the National Longitudinal Survey of Youth 1979 cohort in 1985–2002 and the Cost of Living Index data compiled by the American Chamber of Commerce Researchers Association by using geographic identifiers. Using the merged data, we used panel econometric models to examine the impact of unhealthy food prices on the food stamp-eligible U.S. population. Our results indicate that higher prices for unhealthy food can partially offset the positive association between Food Stamp Program participation and bodyweight among low-income women.

Keywords

body mass index; food prices; food stamp program; obesity; socioeconomic status

Introduction

Although the obesity epidemic affects all racial/ethnic groups and social classes in the United States, populations with low socioeconomic status (SES) bear a disproportionate burden (Grafova 2007; Paeratakul et al. 2002; Winkleby et al. 1998). Identification of the economic mechanisms that promote weight gain among low-income U.S. residents is important information for policymakers to have as they design and implement effective programs to address the U.S. obesity epidemic. The Food Stamp Program (FSP) is the

†The findings and conclusions in this report are those of the author(s) and do not necessarily represent the official position of the Centers for Disease Control and Prevention.

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principal food assistance program in the United States and is designed to provide a nutritional safety net through benefits paid to low-income households or individuals (Guo online first). The U.S. Department of Agriculture (USDA) started to use the new term, Supplemental Nutrition Assistance Program, for FSP on October 1, 2008; we, however, use FSP for consistency with previous literature.

In Fiscal Year (FY) 2008, the FSP served an average of 28.4 million low-income U.S. residents each month and cost \$37.5 billion (USDA 2010a). With so much of the nation's food assistance resources distributed by the program, the impact of participation on the health outcomes of its beneficiaries is a critical public health policy concern (Ver Ploeg 2009). A growing number of studies provide evidence that FSP participation affects a person's dietary intake and increases the risk for obesity (Chen et al. 2005; Gibson 2003; Johnson et al. 1999). Also well-documented is that lower prices for unhealthy foods are positively related to higher obesity prevalence (Chou et al. 2004; Sturm and Datar 2005). However, little is known about whether the prices of unhealthy foods interact with FSP participation and how both factors jointly affect bodyweight status among low-income individuals. Food Stamp benefits increase participants' expendable income on foods. Consequently, those participants might not be as sensitive to the price of unhealthy foods as eligible nonparticipants. Townsend et al. (2001) observed that the FSP benefits distribution cycle can cause binge eating among FSP participants at the beginning of a month and reliance on unhealthy foods during the remaining days. Wilde and Ranney (2000) observed that peak food spending was in the first three days after benefits were received. Given this cycle, lower prices of unhealthy foods can contribute to weight gain among FSP participants in contrast to eligible nonparticipants, whose food consumption patterns do not fluctuate with the FSP benefits distribution cycle. Therefore, whether lower prices for unhealthy foods promote or reduce bodyweight gains among FSP participants, compared with eligible nonparticipants, is unclear.

Recent studies indicate that social and environmental factors contributing to obesity have changed with time, such as mass preparation of food, increasing food portion sizes, and sedentary life styles due to technology advancement (Chang and Lauderdale 2005; Zhang and Wang 2004, 2007). The association between FSP participation, food prices, and bodyweight status might have changed over time as well. Ver Ploeg et al. (2007) compared three rounds of cross-sectional data and determined that the difference in body mass index (BMI) between FSP participants and nonparticipants has decreased across time. However, the trend in the association between FSP participation and bodyweight status might vary because changes have occurred in the fundamental composition of the cross-sectional populations. Therefore, we adopted a longitudinal study to fully understand the association between FSP participation, prices of unhealthy foods, and bodyweight status.

We merged a panel data set, the National Longitudinal Survey of Youth 1979 (NLSY79) cohort, with the Cost of Living Index data published by the American Chamber of Commerce Researchers Association (ACCRA) by using Metropolitan Statistical Area (MSA) codes and Federal Information Processing Standards (FIPS) state and county codes. The merged data set provided detailed information on FSP participation, bodyweight status, and local food prices. We have controlled for individual demographics, region, and

socioeconomic status in all regressions. Our main results indicated that higher prices for unhealthy food were associated with weaker FSP participation effects on bodyweight status among low-income women.

Background

The FSP became a permanent program in 1964 when the U.S. government declared war on poverty (Currie 2003). Although the FSP was originally designed to reduce food insecurity and alleviate hunger among low-income individuals, recent studies indicate that the program might contribute in part to the U.S. obesity epidemic (Chen et al. 2005; Gibson 2003, 2004). Previous studies report that FSP participation increases food expenditure and changes food consumption choices, possibly resulting in weight gain. Whitmore (2002) suggested that FSP participation may encourage additional purchases of some food items, such as soda and juice, if food stamp benefits are larger than what participants would ordinarily spend on these items with cash. Moreover, if FSP participants were given cash instead of food stamps, an estimated 20–30% of them would spend less on food than they do when receiving food stamps. Shapiro (2005) reported that FSP recipients did not treat the benefits as a permanent income source, which might have led to short periods of food overconsumption. In addition, the association between FSP participation and obesity was mainly observed among women. Gibson (2003) estimated that participation in the FSP by low-income women was associated with a 9.1% increase in the probability of obesity. Chen et al. (2005) provided evidence that FSP participation might be positively associated with obesity prevalence among low-income women but cautioned that further studies using longitudinal data sets are needed.

A problem with these studies is that they have not accounted for the influence of local food prices on the association between Food Stamp participation and participants' bodyweight status. Recent studies indicate that relatively lower food prices can contribute to increasing obesity rates (Chou et al. 2004; Lakdawalla and Philipson 2002; Sturm and Datar 2005). Epidemiologic studies reveal that low-cost, energy-dense foods have a lower satiating power and therefore encourage overeating (e.g., Drewnowski and Darmon 2005). However, the impact of food prices on FSP participants' bodyweight status remains unclear (Alston et al. 2009). Intuitively, higher prices for unhealthy foods might reduce FSP participants' consumption of those foods, thus reducing their likelihood of being overweight or obese. Alternatively, higher prices of healthy foods might induce participants to substitute healthy foods with low-cost, unhealthy foods that are usually high in calories and fat. This can result in weight gain among participants. Therefore, fully studying how local food prices interact with FSP participation and prices to affect participants' bodyweight status is important.

Although food prices are a key determinant of household consumption decisions, FSP policies have not fully accounted for the complex role of local food prices in setting benefits. The only adjustment of FSP benefits for differences in food prices are in the states of Alaska and Hawaii and the territories of Guam and the Virgin Islands. For the rest of the U.S. thus far, eligibility for and the level of FSP benefits are based on household size, assets, income, whether persons are aged >60 years or are disabled, and whether children reside in the household. Qualifying households must have gross (net) incomes of <130% (100%) of the federal poverty lines. An eligible household may have less than or equal to \$2,000 of

countable resources (e.g., bank accounts) (USDA 2010b). Some items are not counted in the \$2,000 limit, such as a home, other social welfare benefits, and most retirement plans (Livermore et al., online first). Vehicles are not counted if they are used to generate income. For other vehicles, each adult and each teenager can have one worth up to \$4,650 in fair market value. The upper limit of the asset test can be relaxed to \$3,000 for families with a person aged 60 years or a disabled person. Mabli et al. (2009) summarized recent changes in the eligibility requirements after 2000. On average, the FSP benefit was approximately \$4.15/person/day in Fiscal Year 2009 (USDA 2010c). The monthly allotment of food stamps to an eligible person or household is based on the Thrifty Food Plan, a low-cost model diet plan constructed by the USDA by considering the National Academy of Sciences' Recommended Dietary Allowances and food choices of low-income households (USDA 2007).

Technically, the FSP is not an entitlement program. However, because the U.S. Congress has always allocated sufficient funds for the FSP, it is a *de facto* entitlement program, which means that all eligible households or persons receive benefits (Kuhn et al. 1996). However, not all eligible households participate in the FSP. The participation rate was 66% in fiscal year 2007 (USDA 2009). There are a variety of reasons for nonparticipation, such as the negative stigma associated with receiving welfare, lack of information about eligibility, the availability of other emergency food assistance, and fluctuations in income (Dean and Rosenbaum 2002; Gabor et al. 2002; Martin et al. 2003; Wolkwitz 2007). Therefore, understanding whether any other economic factors (e.g., food prices) contribute to or discourage FSP participation is critical.

Although the interactive effect between food prices and FSP participation on participant bodyweight status should be examined, two challenges exist. First, self-selection to FSP participation can lead to biased estimates of the relation between FSP participation and obesity. A randomized controlled experiment is not possible in the present study to fully measure the causation between FSP participation and bodyweight status. To accommodate this FSP participation endogeneity, we used an instrumental variables approach (see, e.g., Yen et al. 2008). The second challenge is the variability of association between FSP participation and obesity. Although FSP program policy has been relatively stable during the last three decades, other socio-environmental changes, including the association between SES and obesity, have changed in that period (Chang and Lauderdale 2005; Zhang and Wang 2004, 2007). Since SES is a major factor associated with FSP participation, the association between FSP and obesity might have changed as well. Ver Ploeg et al. (2007) reported that the gap between FSP participants' bodyweight status and that of nonparticipants declined during that period. To fully understand the relation between FSP participation, food prices, and bodyweight status, we used a nationally representative data panel and conducted a longitudinal study among low-income women.

Methods

Data

Because no single national data set has complete information on FSP participation, bodyweight status, and local food prices, we merged two national datasets, NLSY79 and ACCRA data, using county and state FIPS codes, for our analysis.

NLSY79—NLSY79 is a survey with a nationally representative sample (12,686 individuals) of non-institutionalized U.S. resident males and females aged 14–22 who were first interviewed during 1979. Follow-up surveys were conducted each year during 1979–1994 and then biennially from 1994 to the present. These data provide detailed information on personal finances, including income, assets, poverty status, and income from public assistance. The NLSY79 data also include geographic identifiers (e.g., respondents' state, county, and metropolitan area of residence) in each survey year. Pregnant women are excluded from our analysis.

ACCRA Price Data—The ACCRA collects quarterly prices of consumer goods in approximately 225 regions throughout the United States. The data includes prices of 21 foods typically consumed at home plus three foods typically consumed away from home. The 21 foods consumed at home include the following:

- meats (T-bone steak, ground beef/hamburger, bacon, frying chicken, and tuna);
- dairy products (whole milk, a dozen eggs, margarine, and parmesan cheese);
- fruits and vegetables (potatoes, bananas, lettuce, sweet peas, tomatoes, peaches, and frozen corn);
- white bread and corn flakes; and
- beverages (coffee, frozen orange juice, and soft drinks).

The three foods consumed away home are a ¼-lb McDonald's® hamburger (McDonald's Corporation, Oak Brook, Illinois), 12–13-inch thin-crust regular cheese pizza at Pizza Hut® (Pizza Hut, Inc., Allison, Texas) or Pizza Inn® (Pizza Inn, Inc., Dallas, Texas), and a fried chicken drumstick and thigh at Kentucky Fried Chicken® (KFC Corporation, Louisville, Kentucky) or Church's Fried Chicken® (Cajun Operating Company, San Antonio, Texas). Both data sets have county and state FIPS codes, which are used as linking variables.

Study periods: The present study focuses on adult female bodyweight. Because respondents were aged 20–28 years in 1985, our study used data from the following years: 1985, 1988, 1990, 1992, 1994, 1996, 1998, 2000, and 2002 (the final year for which data were available for the NLSY79 population when the analyses were conducted).

Definitions of obesity: Body mass index ($BMI = \text{weight [kg]} / \text{height}^2 [\text{m}^2]$) is calculated for each person based on the respondents' weight and height. According to the World Health Organization's recommendation, persons with a $BMI \geq 30$ are considered obese. The 1985 survey was the last year that height was reported. However, since adults usually do not have significant height changes (LaFranchi et al. 1991), we use the height reported by the

respondents in 1985 in the following waves. Bodyweights were self-reported and available in all study years. Cawley (2004) reported no qualitative differences between using measured height and weight versus using self-reported height and weight and that self-reported height and weight are high-quality predictors of actual height and weight. The existing method to correct the self-reported biases in BMI uses the National Health and Nutrition Examination Surveys (NHANES), which has both self-reported and measured body weight and height. However, the NHANES and NLSY79 have different sampling designs. In addition, the NHANES respondents actually knew that they were to be measured when they self-reported their body weight and height, which might have limited the self-reporting biases and presented a different pattern than that among NLSY79 respondents. Hence, we choose not to use the correction method in the present study but to acknowledge the self-reported weight and height as a limitation.

Income and Food Stamp Eligibility: The NLSY79 total net family income variable was used to determine FSP eligibility. Because income includes FSP benefits received, we subtracted the value of food stamps before determining FSP eligibility. Qualifying households have gross incomes of <130% of the federal poverty lines.

Food Stamp participation: Food Stamp participation was determined from responses to the following survey question: “Did the respondent or spouse receive any Food Stamps in the previous year?” Our study used a binary indicator for the variable on FSP participation within the last calendar year. Women eligible for FSP participation were retained in the study sample.

Food price indexes: On the basis of the Energy Density Index (EDI) (Drewnowski and Darmon 2005), healthy foods include fruits, vegetables, dairy products, and corn, whereas unhealthy foods include meats, potatoes¹*, fast-food items, and soft drinks. Weighted food price indexes were calculated by using the expenditure weight provided in ACCRA data on the basis of the Consumer Expenditure Survey (CES)². Because of the strong collinearity between healthy and unhealthy food price indexes, we only included the unhealthy food price indexes in our study. To test the sensitivity of our results to the definition of the price index, we used three food groups to define and calculate the unhealthy food price index (UFPI), as follows:

UFPI1 (fast-food price index): sandwich + pizza + fried chicken.

UFPI2 (less restrictive definition): UFPI1 + soft drink + beef + steak + sausage.

UFPI3 (most general definition): UFPI2 + margarine + sugar + potatoes.

Demographics: Control variables included the respondent's age, marital status, family size, family income, urban/rural residence, and region (Hernandez and Ziol-Guest 2009; Swanson

¹Two-thirds of the daily consumption of potatoes in the U.S. is in the processed form, such as French fries or chips, which are deemed as unhealthy food (Keijbets 2008).

²CES provides the food categories and prices by household income, which can be used for further analyses of the price effect on low-income adults' body weight status.

et al. 2008). We classified marital status as married, never married, separated, divorced, and widowed. Regions of residence were classified as northeast, north central, south, and west.

In summary, there were 6,622 women who were eligible for the Food Stamp Program during 1985 and 2002 and who had complete information for all variables.

Analysis framework

We modeled the association between bodyweight status, FSP participation, and food prices by using two approaches. The first approach treated bodyweight status as a continuous variable and used BMI as the outcome variable. The second approach used a dichotomous measure of bodyweight status and obesity as the outcome and used a logistic regression model for estimation. We specified our baseline model as follows:

$$w = \beta_0 + x\beta + \delta d + \alpha p + \varepsilon, \quad (1)$$

where w is the outcome variable; x is a vector of socio-demographic variables; β is a conformable parameter vector; d is a dummy variable indicating FSP participation; δ is the effect of FSP on bodyweight; p is a price index for unhealthy foods; α is the coefficient to be estimated; and ε is a random error term.

To study the interactive effect between FSP participation and prices of unhealthy food on bodyweight status, an interaction term was added,

$$w = \beta_0 + x\beta + \delta d + \alpha p + \lambda dp + \varepsilon, \quad (2)$$

where λ is the coefficient to estimate the interactive effect on the outcome variable.

If we assume the FSP participation is affected by other individual or household characteristics, we can formulate it as a binary-choice model by

$$d = I(\mu z + \rho m + v > 0) \quad (3)$$

where $I(\cdot)$ is a binary choice function; μ and ρ are parameter vectors; z is a vector of individual characteristics that can affect FSP participation; and m is the instrumental variable, which is correlated to d but is orthogonal to v , where v is an i.i.d. random error with unit variance. Probit model was used to model the FSP participation. With the joint estimation of equations (2) and (3), we expect to account for the self-selection bias of FSP participation on the bodyweight outcome (Chen et al. 2005). Moreover, with the exception of state-level FSP participation, no other valid instruments have complete information during the whole study period. The first stage regression results are: partial $R^2 = 0.02$, F-statistic = 119.06. Therefore, we used the state-level FSP rates as an instrument for individual FSP participation.

To examine the causal effect of prices for unhealthy foods and FSP participation on bodyweight status, we used both fixed effects and random-effects models for the longitudinal data set. The Hausman test can be applied to test the null hypothesis that a random-effects model is as efficient as a fixed-effects model. However, the assumption of

the Hausman test that the fixed-effects model is consistent is no longer valid when measurement errors exist (Lamb 2003). Rejection of the null hypothesis of the Hausman test only demonstrates that the coefficients of the two models are different but not necessarily that one model is superior to the other. Therefore, we present the results of both models for comparison.

In the panel analyses, the sampling weight was not used because of the following concerns: Theoretically, the weighting scheme might change with time for the longitudinal data set, and no guideline exists on handling such situations. Meanwhile, the fact that the regressions are performed on samples stratified by sex and that income status is included in the regression might alleviate the concerns regarding sampling bias, which largely relate to sex and income. All statistical analyses are performed with xt series of commands in STATA® 9 SE (StataCorp 2005).

Results

Table 1 summarizes the demographic characteristics and bodyweight status of FSP participants and eligible nonparticipants across time. Literature indicates that no statistically significant association exists between FSP participation and body weight status among men (Chen et al. 2005; Gibson 2003); therefore, we only present the results regarding low-income women in this study. Our results indicate that the mean household income among FSP participants was substantially lower than among eligible nonparticipants, which indicates that lower-income women are more likely to receive FSP benefits. A racial/ethnic disparity in FSP participation exists. The percentage of blacks among FSP participants was higher than that among FSP nonparticipants, although the percentage of Hispanics among FSP participants and nonparticipants was not substantially different. On average, the percentage of blacks among participants was 10 percentage points greater than among eligible nonparticipants. For example, in 1994, a total of 45.5% of FSP participants were black, whereas only 17.9% of nonparticipants were black. Similarly, the mean percentage of Hispanics among FSP participants was greater than the mean percentage of Hispanics among nonparticipants. No age disparities were apparent between the two groups across time, except during 1985. Considerable gaps in bodyweight status existed between FSP participants and eligible nonparticipants across time. On average, participants' BMIs were 2 points greater than the BMIs of nonparticipants. These BMI gaps were statistically significant, except during 1998. When obesity is used as the outcome, the difference in obesity prevalence between the two groups was not as great as the difference in BMI. During 1988, 1990, and 1994 only, the obesity prevalence among participants was substantially higher than that among eligible nonparticipants. However, during other years, the gaps were much smaller, approximately 5 percentage points, and the difference was not statistically significant. Therefore, the choice of outcome measures directly affected the measurement of FSP participation effects on bodyweight status among participants.

Table 2 summarizes the panel econometric results, with BMI as the outcome variable and three UFPIs. We present results of both fixed and random effects models. For both models and three definitions of unhealthy food prices, FSP participation positively contributed to BMI, although the coefficients of the random effects model were approximately double

those of fixed effects models. The signs of UFPI2 and UFPI3 were both negative, which means higher unhealthy food prices were associated with lower BMI, but the sign of UFPI1 was positive. However, all those coefficients of food prices were not significantly different from zero. Interestingly, the coefficients of interactive terms across models were statistically significant and negative, which signifies the offsetting effects of unhealthy food prices and FSP participation.

Table 3 presents the results of using obesity as the outcome variable. The odds ratios (ORs) of FSP participation were all >1 , whereas ORs were statistically significant with random effects models but not significant with fixed effects models. ORs of UFPI1 were <1 , indicating the negative effect of fast food prices on obesity risk. However, the ORs of UFPI1 in both fixed and random effects models were not significantly different from 1. ORs of UFPI2 and UFPI3 were all considerably <1 . The OR estimates of the interaction terms in all models were <1 but were not statistically significant.

Tables 4 and 5 present the second-stage regression results with the state participation rates as the instrumental variables. In Table 4, the coefficients of FSP participation were still positive, although those of the fixed effects models were no longer significant. The coefficients of UFPI1 were negative but not significantly different from zero in both fixed and random effects models. The coefficients of UFPI2 and UFPI3 were all negative in both models. However, those of the random effects models were highly significant, whereas those of the fixed effects models approached 10% significance levels. The interaction terms were all negative but not statistically significant in fixed effects models. In random effects models, the interaction term was not significant with UFPI1 but was highly significant with UFPI2 and UFPI3.

The patterns of signs and significance of ORs in Table 5 were similar to those in Table 4. ORs of FSP participation were all >1 , indicating higher risk for obesity with FSP participation. However, ORs of FSP participation were statistically significant in random effects models but not fixed effects models. ORs of UFPI1 were not significantly different from 1 in both fixed and random effects models. However, ORs of UFPI2 and UFPI3 were significantly <1 in both models. The pattern of interactive terms was similar to that of price coefficients. The interactive term of UFPI1 was not significantly different from 1, whereas those of UFPI2 and UFPI3 were significantly <1 , regardless of which panel model we used.

Discussion

Our analyses of the panel data of NLSY79 cohorts indicate the considerable interactive effects between prices of unhealthy foods and FSP participation on bodyweight status among low-income women. Drewnowski and Specter (2004) stated that poverty was positively associated with food insecurity and obesity. With the need for lower food expenditures, low-income consumers tend to depend more on energy-dense foods, which can be low-priced and provide high palatability. With respondents' participation in the FSP, income spent on energy-dense foods potentially increases because of the income effect. If foods are ineligible for FSP benefits, FSP benefits cannot be used to purchase those foods. The findings of our study indicate that FSP effects on bodyweight status of participants are

not isolated, but they are affected by other economic factors (e.g., food prices). Our results suggest an economic mechanism that might contribute to preventing bodyweight gain among low-income populations. Significant differences in regional food prices can alter FSP effects on BMI, perhaps resulting in greater obesity as prices of unhealthy foods decrease across regions. This observation might contribute to an explanation of dramatic geographic variations in obesity prevalence across the United States (Ford et al. 2004).

This study also provides evidence regarding the ongoing debate on the so-called *fat tax*, conceived as a means to reduce fat intake and improve diet quality. Researchers provide evidence that a steep sales tax on soft drinks, snack foods, or fast foods will reduce sugar and fat intake among the general population, thereby reducing bodyweight gain in the long run (French et al. 1997; Jacobson and Brownell 2000). Moreover, they argue that such a minor tax can generate substantial revenues to subsidize the production and consumption of healthy foods (Jacobson and Brownell 2000). Twenty-seven states have passed or proposed different legislative measures that impose taxes on the sale or distribution of soft drinks and snacks. For example, Arkansas taxes \$2 on each gallon of soft drink syrup or \$0.21 on each gallon of bottled soft drinks (Chouinard et al. 2007). However, because of the inelastic nature of the demand for unhealthy foods, a minor tax will likely have only a limited impact on dietary quality, whereas a major tax on a full range of unhealthy snacks might not be acceptable by consumers (Kuchler et al. 2005). None of these arguments directly address the impact of snack food and soft drink taxes on the diets of low-income populations, who are particularly sensitive to food prices as compared with other income groups. This study presents some evidence for the first time that a potential increase in the price of unhealthy foods can partially offset the undesirable impact of FSP participation on BMI and obesity. Before this study, researchers proposed nutritional education programs as possible tools to reduce obesity among FSP participants (Gibson 2003). However, our study provides evidence to support one more policy tool to eliminate bodyweight disparity between FSP participants and nonparticipants. Moreover, the revenue from a tax on snack foods can provide direct funding for the nutrition education plans. Therefore, recognizing the negative interactive effect between unhealthy food prices and FSP participation on bodyweight status is important.

This study also raises a critical question regarding how to effectively manage the FSP across the country to reduce the potential negative impact on health outcomes. Ver Ploeg et al. (2007) recommend that a potential cut in FSP benefits might be a viable solution to reduce consumption of less nutritious foods. This study presents another option that adjusts the FSP benefits on the basis of unhealthy food prices. The price of unhealthy food is an important contributor to our obesogenic environment, which has been blamed for fueling the U.S. obesity epidemic (Hill et al. 2003; Popkin et al. 2005). Adjusting the FSP benefits by region might be a feasible policy instrument to disentangle the association between FSP participation and obesity. Further research is needed to quantify an accurate adjustment formula to satisfy the regional price variation.

The definition of unhealthy food prices and panel model selection affect statistical inference. Although fast foods are representative of unhealthy food prices, the price effects of these foods were not substantial among low-income populations. However, using the more general

unhealthy food price definitions reveals a significant negative impact of food prices. Our price data were only at the county level, which might not accurately describe the food prices that consumers face. This limitation might also affect the estimation of food prices and their effect on bodyweight status. Future studies should collect more food price data, especially among low-income populations, to fully understand the mechanism. The difference between fixed and random effects models was most reflected in the effects of FSP participation. The estimations of fixed effects models depend on sufficient changes across time. However, if no changes in FSP participation status or bodyweight status occur, the fixed effects models might not fully estimate the FSP participation effect. Consistent with previous literature, self-selection bias can be a potentially confounding factor regarding the BMI disparity between FSP participants and eligible nonparticipants. Although randomization is the only way to fully account for the bias, the de facto entitlement nature of FSP does not allow for such an experimental design. A few experimental designs have been proposed to surmount the hurdles (Wilde 2007), but no unanimous agreement exists on the best approach to address the problem. Further studies are needed to determine the causal relation between FSP participation and obesity.

The potential bias in self-reported weight and height is a limitation of the study. Cawley (2004) has suggested that the results obtained using the self-reported BMI and the corrected BMI are qualitatively consistent, particularly when we stratify by gender groups. Since NLSY79 interviewers did not physically examine respondents' bodyweight measures, it is challenging to use other national datasets, such as the National Health and Nutrition Examination Survey (NHANES), to calibrate the self-reported bias. NHANES and NLSY79 differ in terms of sampling framework and measurement procedures and it remains unclear how to apply statistical inference with another dataset's estimate. Self-reported weight and height have been widely used in longitudinal studies (Huang et al. 1998) and in national monitoring surveys (Mokdad et al. 2001). Therefore, our study provided preliminary results based on self-reported body measures.

We studied the interactive effect of prices for unhealthy food and FSP participation on bodyweight status among low-income women. We concluded that FSP participation contributed to higher BMI among participants and a higher risk for obesity. Therefore, higher prices for unhealthy foods had a protective effect on bodyweight status. The statistically significant interaction terms provide evidence that increased prices for unhealthy foods among low-income women potentially offset the undesirable impact of FSP participation on obesity. Our study provides support for the idea of taxing unhealthy foods as a partial remedy for the U.S. obesity epidemic. Moreover, our study demonstrates that the adjustment of FSP benefits based on regional prices for unhealthy foods is an optional policy intervention to reduce the disparity of obesity between FSP participants and eligible nonparticipants. More accurate data describing the food consumption environment for low-income populations is needed to fully understand the economic mechanisms contributing to the U.S. obesity epidemic.

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Table 1
 Characteristics of FSP female participants and eligible FSP female nonparticipants ($n = 6,622$)

Year	No.	Household income		Hispanic (%)		Black (%)		Age		BMI		Obese (%)	
		FSP	EN	FSP	EN	FSP	EN	FSP	EN	FSP	EN	FSP	EN
1985	879	6835.0 (186.1)	7886.6 (209.8)**	10.8 (1.9)	7.1 (1.1)	39.2 (2.9)	17.5 (1.6)**	23.8 (0.1)	23.0 (0.1)**	24.2 (0.3)	23.0 (0.2)*	10.7 (1.8)	9.0 (1.2)
1988	677	9095.2 (356.5)	111652.8 (346.6)**	14.8 (2.4)	12.0 (1.5)	39.6 (3.3)	18.1 (1.8)**	27.2 (0.1)	27.2 (0.1)	26.3 (0.4)	24.5 (0.3)**	19.1 (2.6)	12.3 (1.5)*
1990	965	9731.3 (300.1)	13264.2 (313.3)**	11.5 (1.7)	7.4 (1.0)	44.3 (2.7)	18.3 (1.5)**	29.4 (0.1)	29.4 (0.1)	26.4 (0.3)	24.8 (0.2)**	23.4 (2.3)	16.0 (1.5)**
1992	865	10570.7 (310.8)	15675.3 (400.7)**	13.5 (1.8)	9.5 (1.3)	41.0 (2.6)	20.6 (1.8)**	31.3 (0.1)	31.2 (0.1)	26.9 (0.3)	25.6 (0.3)*	25.8 (2.3)	20.4 (1.8)*
1994	907	12058.2 (361.3)	16760.5 (414.3)**	13.6 (1.7)	8.1 (1.3)	45.5 (2.5)	17.9 (1.7)**	33.1 (0.1)	33.1 (0.2)	27.9 (0.4)	26.1 (0.3)**	32.2 (2.4)	22.2 (1.8)**
1996	686	12178.2 (464.9)	15723.6 (459.3)**	13.9 (2.5)	8.6 (1.3)	43.2 (3.5)	24.8 (2.0)**	35.1 (0.1)	35.0 (0.1)	28.8 (0.6)	26.9 (0.3)**	31.1 (3.3)	26.8 (2.0)
1998	517	17093.4 (1649.3)	16586.4 (515.5)**	12.5 (4.7)	8.8 (1.3)	38.4 (6.9)	26.9 (2.1)**	36.8 (0.1)	36.7 (0.1)	29.2 (1.1)	27.3 (0.3)	36.6 (6.9)	29.3 (2.1)
2000	581	11541.9 (609.9)	15180.0 (470.0)**	12.8 (3.3)	9.5 (1.3)	46.0 (4.9)	24.1 (2.0)**	38.9 (0.1)	38.9 (0.1)	29.5 (0.6)	27.9 (0.4)*	32.6 (4.6)	29.0 (2.1)
2002	545	12684.7 (794.6)	16393.2 (517.7)**	11.1 (3.6)	10.1 (1.4)	43.5 (5.6)	25.1 (2.0)**	41.0 (0.1)	40.9 (0.1)	30.0 (0.9)	27.3 (0.3)**	36.7 (5.5)	30.0 (2.1)

Notes:

BMI: Body mass index; FSP: FSP participants; EN: eligible FSP nonparticipants.

(.) standard errors.

* $p < .05$.

** $p < .01$.

*** $p < .001$.

Table 2

Fixed and random effects models of the association between FSP participation, unhealthy food prices, and BMI among FSP-eligible women[†]

Dependent variable	BMI					
	UFPII			UFPI2		
	Estimates	S.E.	p	Estimates	S.E.	p
Price indexes						
Fixed effects model						
FSP participation	0.28**	0.11	0.01	0.26	0.12*	0.02
Unhealthy Food Price Index	0.06	0.05	0.23	-0.01	0.02	0.92
FSP participation · Unhealthy food prices	-0.13*	0.06	0.03	-0.06	0.03*	0.03
Random effects model						
FSP participation	0.56***	0.11	<0.001	0.54	0.11***	<0.001
Unhealthy Food Price Index	0.04	0.05	0.36	-0.01	0.02	0.54
FSP participation · Unhealthy food prices	-0.11*	0.05	0.04	-0.05	0.03	0.06

Notes:

BMI: Body mass index; UFPI1: Unhealthy food price index, fast food prices; UFPI2: Unhealthy food price index, less restrictive definition; UFPI3: Unhealthy food price index, general definition; S.E.: Standard error; FSP: Food Stamp Program.

* p < .05.

** p < .01.

*** p < .001.

[†] All models were adjusted for age, family size, income, urbanization, region, and marital status.

Table 3
Fixed effects and random effects models of the association between FSP participation, unhealthy food prices, and obesity status among FSP-eligible women[†]

Dependant Variable	Obesity					
	UFPI1		UFPI2		UFPI3	
Price Indexes	Odds ratios	95% CI	Odds ratios	95% CI	Odds ratios	95% CI
Fixed effects model						
FSP participation	1.46	(0.96 2.21)	1.35	(0.88 2.08)	1.37	(0.89 2.09)
Unhealthy Food Price Index	0.89	(0.60 1.32)	0.84	(0.76 0.94)	0.86	(0.79 0.95)
FSP participation · Unhealthy food prices	0.59	(0.19 1.84)	0.99	(0.86 1.14)	1.00	(0.89 1.13)
Random effects model						
FSP participation	1.81	(1.38 2.37)	1.69	(1.29 2.21)	1.68	(1.28 2.20)
Unhealthy Food Price Index	0.83	(0.59 1.16)	0.94	(0.89 1.00)	0.95	(0.90 0.99)
FSP participation · Unhealthy food prices	0.98	(0.62 1.55)	0.97	(0.90 1.04)	0.97	(0.91 1.04)

Notes:
UFPI1: Unhealthy food price index, fast food prices; UFPI2: Unhealthy food price index, less restrictive definition; UFPI3: Unhealthy food price index, general definition; CI: confidence interval; FSP: Food Stamp Program.
* p < .05.
** p < .01.
*** p < .001.
[†] All models were adjusted for age, family size, income, urbanization, region, and marital status.

Table 4

Two-stage fixed and random effects models of the association between FSP participation, unhealthy food prices, and BMI among FSP-eligible women with state participation rates as the instrumental variable[‡]

Dependant Variable	BMI					
	UFPI1			UFPI2		
Price indexes	Estimates	S.E. [‡]	p	Estimates	S.E. [‡]	p
Fixed effects model						
FSP participation [§]	0.17	0.17	0.31	0.09	0.13	0.59
Unhealthy Food Price Index	-0.03	0.03	0.36	-0.05	0.03	0.09
FSP participation · Unhealthy food prices	-0.01	0.02	0.68	-0.03	0.02	0.11
Random effects model						
FSP participation [§]	0.29***	0.07	<0.001	0.20	0.11	0.06
Unhealthy Food Price Index	-0.03	0.14	0.78	-0.05***	0.01	<0.001
FSP participation · Unhealthy food prices	-0.01	0.05	0.98	-0.03***	0.01	<0.001

Notes:

BMI: Body mass index; UFPI1: Unhealthy food price index, fast food prices; UFPI2: Unhealthy food price index, less restrictive definition; UFPI3: Unhealthy food price index, general definition; S.E.: Standard error; FSP: Food Stamp Program.

* p < .05.

** p < .01.

*** p < .001.

[‡] All models were adjusted for: age, income, urbanization, region, and marital status.

[‡] Bootstrapped standard errors.

[§] Predicted FSP participation from probit model.

Table 5

Two-stage fixed and random effects models of the association between FSP participation, unhealthy food prices, and obesity status among FSP-eligible women[†]

Dependant variable	Obesity					
	UFPI1		UFPI2		UFPI3	
Price indexes	Odds ratios	95% CI [‡]	Odds ratios	95% CI [‡]	Odds ratios	95% CI [‡]
Fixed effects model						
FSP participation [§]	1.58	(0.79 3.19)	1.06	(0.65 1.73)	1.05	(0.40 2.72)
Unhealthy Food Price Index	0.81	(0.31 2.08)	0.77	(0.68 0.88)	0.80	(0.77 0.84)
FSP participation · Unhealthy food prices	0.95	(0.47 1.95)	0.91	(0.87 0.97)	0.93	(0.86 1.00)
Random effects model						
FSP participation [§]	1.88	(1.45 2.41)	1.60	(1.16 2.23)	1.58	(1.32 1.90)
Unhealthy Food Price Index	0.87	(0.70 1.08)	0.90	(0.85 0.96)	0.91	(0.89 0.95)
FSP participation · Unhealthy food prices	1.03	(0.88 1.20)	0.96	(0.93 0.99)	0.97	(0.95 0.99)

Notes:

UFPI1: Unhealthy food price index, fast food prices; UFPI2: Unhealthy food price index, less restrictive definition; UFPI3: Unhealthy food price index, general definition; CI: Confidence interval; FSP: Food Stamp Program.

* p < .05.

** p < .01.

*** p < .001.

[†] All models were adjusted for: age, income, urbanization, region, and marital status.

[‡] Bootstrapped 95% confidence interval.

[§] Predicted FSP participation from probit model.